

Outcome of surgical embolectomy in patients with massive pulmonary embolism with and without cardiopulmonary resuscitation



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Abstract

Introduction: Pulmonary embolism is a challenging critical cardiovascular disease with high morbidity and mortality. Surgical embolectomy has favorable results in patients with massive pulmonary embolism.

Aim: To study the outcome of embolectomy in patients with massive pulmonary embolism.

Material and methods: In this single-center, retrospective study, 36 patients including 14 male and 22 female patients with a mean age of 50.80 ± 18.89 years with acute pulmonary embolism who underwent surgical pulmonary embolectomy from January 2011 to January 2016 were included. The medical records of all patients were reviewed for demographic and preoperative data and postoperative outcomes.

Results: Common risk factors for acute PE were major surgery within 3 months and deep vein thrombosis. The most common presenting symptoms of patients were dyspnea, followed by chest pain and syncope. Mean duration of hospitalization was 14.76 ± 8.69 days and mean operation duration was 4.47 ± 1.54 h. Mean time from admission to embolectomy was 6.58 ± 1.13 h. Ten (27.8%) patients died during the operation including 3 cases with cardiopulmonary resuscitation prior to surgery and 2 cases with severe cardiogenic shock. Patients who survived were followed for 6 months. The mortality rate during follow-up was 15.4%; all 4 patients died during follow-up period due to metastatic cancer. No pulmonary embolism recurrence were seen.

Conclusions: Although surgical embolectomy mostly was done for high risk patients, it had good in-hospital and excellent mid-term outcomes.

Key words: pulmonary embolism, surgical embolectomy, treatment outcome, mortality, success rate.

Streszczenie

Wstęp: Zatorowość płucna jest bardzo niebezpieczną i trudną w leczeniu chorobą układu krążenia o wysokich wskaźnikach chorobowości i śmiertelności. Chirurgicalna embolektomia wiąże się z korzystnymi wynikami u pacjentów z masywnymi zatorami płucnymi.

Cel: Zbadanie wyników embolektomii u tego typu pacjentów.

Materiał i metody: W jednośrodkowym, retrospektywnym badaniu uczestniczyło 36 pacjentów (14 mężczyzn i 22 kobiety, wiek średnio $50,80 \pm 18,89$ roku) z ostrą zatorowością płucną, którzy przeszli zabiegi chirurgicznej embolektomii płucnej między styczniem 2011 a styczniem 2016 r. Dokumentację medyczną pacjentów przeanalizowano pod kątem danych demograficznych i przedoperacyjnych oraz wyników pooperacyjnych.

Wyniki: Częstymi czynnikami ryzyka wystąpienia ostrego zatoru płucnego były poważna operacja chirurgiczna w ciągu 3 miesięcy oraz zakrzepica żył głębokich. Wstępnymi objawami najczęściej zgłaszanymi przez pacjentów były kolejno: duszności, bóle klatki piersiowej i omdlenia. Średni czas hospitalizacji wyniósł $14,76 \pm 8,69$ dnia, a średni czas zabiegu $4,47 \pm 1,54$ godziny. Średni czas od przyjęcia pacjenta do embolektomii wyniósł $6,58 \pm 1,13$ godziny. Dziesięciu (27,8%) pacjentów zmarło w trakcie zabiegu; u 3 z nich wykonano przed zabiegiem resuscytację krążeniowo-oddechową, a u 2 doszło do ciężkiego wstrząsu kardiogenego. Pacjentów, którzy przeżyli, obserwowano przez 6 miesięcy. Odsetek śmiertelności w czasie obserwacji wyniósł 15,4%; wszyscy 4 pacjenci zmarli w trakcie obserwacji z powodu przerzutowego raka. Nie zaobserwowano przypadków nawrotów zatorowości płucnej.

Wnioski: Mimo że chirurgiczną embolektomię wykonywano głównie u pacjentów z wysokim ryzykiem, zastosowana metoda wiązała się z dobrymi wynikami wewnątrzszpitalnymi oraz doskonałymi wynikami średnioterminowymi.

Słowa kluczowe: zator płucny, embolektomia chirurgiczna, wynik leczenia, śmiertelność, wskaźnik skuteczności terapii.

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Introduction

Despite advances in diagnostics and therapeutics, pulmonary embolism (PE) is one of the most critical cardiovascular diseases and is associated with high morbidity and mortality [1–4]. Massive PE is a life-threatening condition with a mortality rate of 31–70% [5, 6]. Rapid intervention is necessary to restore pulmonary blood flow and stabilize the hemodynamic state. Pulmonary embolism is usually treated medically with anticoagulation; thrombolysis and surgical embolectomy are other treatments reserved for patients with massive PE and hemodynamically unstable patients [7, 8].

Today surgical embolectomy is a therapeutic option for patients who present with cardiogenic shock, have contraindications to thrombolysis or who have persistent hypotension after initial therapy [9, 10]. Previously, some researchers have reported that surgical embolectomy had a high mortality rate ranging from 16% to 64% [4]. By improvement in surgical techniques and experience of surgeons, recent studies have shown favorable results in massive PE with preserved hemodynamics with evidence of moderate to severe right ventricle (RV) dysfunction on echocardiography [11–17].

Aim

We conducted a retrospective single-center study of patients who underwent surgical embolectomy to investigate the efficacy of this treatment in PE patients.

Material and methods

In this single-center, retrospective study, 36 patients over 18 years old with a definite diagnosis of acute PE who underwent surgical pulmonary embolectomy from January 2011 to January 2016 were included. The study protocol was approved by the Tabriz University of Medical Sciences institutional review boards.

Patients' clinical records were reviewed and demographic information, initial presentation and symptoms, risk factors, methods of diagnosis, localization of throm-

botic material, indication for operation, mortality, and morbidity were recorded. Pulmonary embolism diagnosis was confirmed by 36-slice computed tomography (CT) angiography in all patients. Patients with persistent O₂ saturation \leq 90% and/or systolic blood pressure (BP) \leq 90 or a drop of $>$ 40 mm Hg from baseline BP lasting for 15 min or requiring inotropic support with concomitant massive PE findings in computed tomography (CT) angiography (new thrombus formation in the common pulmonary artery trunk or right or left main pulmonary artery) and RV enlargement received fibrinolytic therapy as the first line management and surgical embolectomy was done when dyspnea, low systolic BP and/or O₂ saturation \leq 90% continued after fibrinolytic therapy (defined as fibrinolytic therapy failure) or when there was a contraindication to fibrinolytic therapy. We used intravenous fibrinolytic therapy and interventional angiography was not done for patients. Low molecular weight or unfractionated heparin was administered to normotensive patients with O₂ saturation $>$ 90%. A loading dose of 250,000 U of streptokinase over 30 min following 100,000 U/h for 24 h was used for most patients when fibrinolytic therapy was indicated. Recently fibrinolytic therapy protocol in our center has been changed to 15 mg reteplase in two separate stat doses with a 30-minute interval, which has been used in 5 patients.

Surgical technique

The surgery was performed within 72 h of the initial thrombolysis through median sternotomy. After cardiopulmonary bypass a longitudinal incision was performed on the main pulmonary artery trunk, extending the incision into the left pulmonary artery, and additional arteriotomy of the right pulmonary artery was performed when indicated. Using forceps, thrombus removal was started, continuing to extract thrombi inside segmental pulmonary arteries if necessary. In some patients and after inducing moderate hypothermia, extracorporeal circulation was stopped for up to 30 min for better thrombus visualization and its complete extraction.

Post-intervention treatment

All patients received IV unfractionated heparin immediately after surgery or 2–4 h after streptokinase when the activated partial thromboplastin time (aPTT) reached $<$ 80 ms, or 15 min after recombinant tissue plasminogen activator (rTPA) therapy with a therapeutic aPTT ratio of two to three times the control value. Results are expressed as mean \pm SD or percentage.

Results

Thirty-six patients including 14 (38.9%) male and 22 (61.1%) female patients with a mean age of 50.80 ± 18.89 years were evaluated. Mean time from admission to embolectomy was 6.58 ± 1.13 h. Risk factors for development of PE are presented in Table I. Common risk factors were major surgery within 3 months and deep vein thrombosis. The most common presenting symptoms of patients were dyspnea, followed by chest pain and syncope (Tab. II).

Tab. I. Risk factors for pulmonary embolism

Condition	Number (%)
Major surgery within 3 months	15 (41.7)
Deep vein thrombosis	14 (38.9)
Malignancy	4 (11.1)
Bedridden status	3 (8.3)

Tab. II. Presenting symptoms of patients

Condition	Number (%)
Dyspnea	26 (72.2)
Syncope	2 (5.6)
Chest pain	2 (5.6)

Mean CPKMB, CPK and CTnl were 30.47 ± 19.75 , 93.58 ± 26.82 and 0.45 ± 0.16 , respectively. Mean systolic and diastolic blood pressure were 95.37 ± 16.71 and 59.37 ± 11.41 mm Hg, respectively. Mean heart rate was 103.35 ± 17.63 bpm.

ECG findings included T invert in V1–V3 (15 cases, 41.7%) and S1Q3T3 pattern (16 cases, 44.4%). Echocardiography findings showed RV enlargement in 29 (80.6%) cases and RV dysfunction in 25 (69.4%). Mean RV size was 4.33 ± 0.95 . Mean left ventricular ejection fraction (LVEF) was $50.75 \pm 6.01\%$.

Mean duration of hospitalization was 14.76 ± 8.69 days and mean operation duration was 4.47 ± 1.54 h. Indications for surgical embolectomy are summarized in Table III.

Ten (27.8%) patients died during the operation including 3 cases with cardiopulmonary resuscitation (CPR) prior to surgery and 2 cases with severe cardiogenic shock. One patient with active bleeding and one with transit clot in the RV developed severe cardiogenic shock before surgery and the operation was done for them before hemodynamic stability. The mortality rate of surgical embolectomy was 27.7%. After excluding the 5 above-mentioned cases, the mortality rate was 16.1%. Long duration of CPR and cardiogenic shock and their induced ischemic state can result in irreversible cardiac damage and death regardless of successful or unsuccessful embolectomy. We excluded these patients to determine the exact surgical embolectomy mortality. Causes of death were right ventricle failure in all cases except 1 patient with post-operative acute renal failure and preoperative distal emboli resulting in lower extremity gangrene.

Patients who survived were followed for 6 months. The mortality rate during follow-up was 15.4%; all 4 patients died due to metastatic cancer. No recurrent PE was detected.

Discussion

Pulmonary embolism is a challenging medical condition with significant morbidity and mortality. Massive PE is life threatening and requires aggressive management. Thrombolysis is the treatment of choice for massive PE [17]. Today surgical embolectomy is the second choice of treatment, and due to its acceptable outcomes its use is increasing for the management of massive and sometimes sub-massive PE [18, 19].

We evaluated 36 cases with massive PE undergoing primary or rescue surgical embolectomy. Mortality in our study was 27.7%, and after excluding patients under CPR or those with a prolonged state of shock mortality decreased to 16.1%, which are similar to most previous studies. Recent studies have indicated lower mortality and morbidity rates for surgical embolectomy with a mortality rate between 3.6% and 29% [17–19]. While in stable patients mortality is very low, in unstable patients the situation is different. Neely *et al.* reported the largest case series of surgical embolectomy of 115 patients with submassive and massive PE with a mortality rate of 6.6% for all and 10.2% for massive PE [17]. Alizadeh *et al.* studied 12 massive PE patients and reported a mortality rate of 16.6%. One of their patients died during the surgery and one in the intensive care unit [11].

Tab. III. Indications for surgical embolectomy

Indications for surgical embolectomy	Total patients with embolectomy 36 (100%)	Patients died during or after surgery 10 (100%)
Recent surgery	15 (41.7%)	2 (20%)
Transit clot in RV or RA	12 (33.3%)	3 (30%)
Failure of thrombolysis	4 (11.1%)	1 (10%)
Active bleeding	2 (5.6%)	1 (10%)
Post CPR	3 (8.3%)	3 (30%)

RV – right ventricle, RA – right atrium

It is reported that the mortality rate increases if CPR is required. Patients with massive PE, who presented with cardiac arrest and required CPR, had a mortality of up to 70% within the first hour of presentation [14, 20]. A mortality rate of 57% for patients who required CPR was reported by Dauphine and Omari [20], while Yavuz *et al.* [14] reported a higher mortality rate of 75% for patients with CPR.

Janata *et al.* reported a mortality rate of 85–95% in patients with cardiac arrest [21]. Leitner *et al.* reported that the cause of this high mortality could be coagulopathy similar to disseminated intravascular coagulation (DIC) [22].

Hence, the underlying cause of PE should be evaluated in these patients. In our study, ten patients died during the surgery; three of them had CPR prior to surgery. In fact, the mortality rate for patients requiring CPR before surgery was 100%. Previous reports have noted that preoperative cardiogenic shock is an important predictor of survival after massive PE [8]. In our study also 2 patients with prolonged cardiogenic shock died because of RV failure.

It seems that because of many confounding factors such as duration of CPR, the experience of the CPR team, the time between cardiac arrest and operation [8], the distance of the operating room from the emergency room, and multi-organ damage induced by a state of shock, reporting the exact mortality for surgical embolectomy in very unstable patients is not easy.

Using RV support after embolectomy with delay sternal closure may be helpful in patients with post-operative RV failure – a technique not available in some centers [23]. Most of the patients in our study died because of post-operative RV failure. Right ventricle failure was the main cause of surgical embolectomy failure and mortality in our study. Continuous RV failure despite adequate embolectomy can be explained by several factors. In healthy people, the RV cannot continue contraction against a mean pressure > 40 mm Hg [24]. In some cases a large burden of clot in small distal arteries, not suitable for embolectomy, especially when it affects both lungs, can still prevent RV afterload reduction despite adequate proximal embolectomy.

Right ventricle ischemia seems to be the second most important factor. By increasing RV end diastolic pressure the RV blood supply is decreased. Possible coronary artery obstruction and hypotension aggravate the insufficient

blood supply [25]. The key point in this setting is the time. If surgical embolectomy is done when irreversible RV ischemic damage happens, the mortality will be high. Also infarct size is important. La Vecchia *et al.* found that ctnI was the strongest independent predictor of death in massive PE [26]. Hence, we need more investigations to define the golden time for surgical embolectomy in those with a state of shock and cardiac arrest undergoing CPR.

We observed a success rate of 84.6% during 6-month follow-up. Similar to our findings, Leacche *et al.* [4] reported 3-year survival of 83% in 47 patients; and Fukuda *et al.* [27] also reported 10-year survival of 84% in 19 patients.

Prompt removal of emboli can save the life of a patient with acute massive PE. So, rapid evaluation of patients with massive PE, especially before cardiac arrest starts, would possibly increase the success rate.

This study has several limitations. This was a retrospective nonrandomized study and all data were collected from medical records, so in some cases laboratory findings were not available. The study included a small sample size of massive PE and no submassive cases, which limits its generalizability. As an observational study, there were no other nonsurgical groups for comparison.

Conclusions

Although surgical embolectomy is performed mostly for high-risk patients, it has good in-hospital and excellent mid-term outcomes.

Disclosure

Authors report no conflict of interest.

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